[0095] The piezo power capacity and output power is determined, at least in part, by the number or amount of piezo fibers, the size and form factor of the fibers/composite, and the mechanical forces (stress and strain, F=N) and frequencies (VIB=Hz). Useful amounts of power may be measured in micro and milliwatt levels (and in some cases nanowatts).

[0096] As way of example, an exemplary wireless telephone (cellular telephone) having GSM terminals may have a stand by mode of about 10 milliwatts, talking mode of about 300 milliwatts, and shut down mode of about 100 milliwatts. An exemplary digital assistant (PDA) as similar, as are Bluetooth devices. MP3 players typically use about 100 mW to power the headphones and 10 mW to process.

[0097] A typical single, piezoelectric fiber composite (PFC) may generate voltages in the range of about 40 Vp-p from vibration. A typical single, PFCB (bimorph) may generate voltages in the range of about 400-550 Vp-p with some forms reaching outputs of about 4000 Vp-p. As way of illustration, VSSP produced piezo fibers have the ability to produce about 880 mJ of storable energy in about a 13 second period when excited using a vibration frequency of 30 Hz. Other embodiments have the ability to produce about 1 J of storable energy. These energy levels are enough power to operate, for example, an LCD clock that consumes about 0.11 mJ/s for over approximately 20 hours.

[0098] The table below illustrates exemplary energy harvesting results for a plurality of different types of energy harvesting systems. As can be seen for the exemplary results, piezoelectric fiber composites (PFC) may offer superior power generation and storage possibilities over other types of energy harvesting systems.

Group	Transducer	Dimen. (cm)	Measure method	Mode	V_{p-p}	Peak Power	Stored energy in 13 s(mJ)
Kyushu NIRI, Japan	PZT-5A disk	D-2.4 T = 0.3	Ball drop	d_{33}	120	450 μW	NA
MIT	Multilayer bimorph PVDF	8 × 10	walking	d_{33} & d_{31}	60	20 mW	17
MIT/NASA	Thunder	7 × 9.5 × 0.05	walking	d_{31} & d_{15}	150	80 mW	110
Ocean Power Tech., Inc.	EEL PVDF	Five 132 × 14 × 0.04	Ocean waves	d_{33} & d_{15}	3	—	NA
Univ. of Pittsburgh	PZT-5A plate	1 × 1 × 0.0009 0.0009	Tension	d_{31}		2.3 μW	0.3
Penn State University	Quickpack	5 × 3.8 × 0.07	Vibration	d_{33}	43	—	169
Advanced Cerametrics, Inc.	PFCB	13 × 1 × 0.1	Vibration (30 Hz)	d_{33}	550	120 mW	1,000

[0099] Preferably, the power output is scalable by combining two or more piezo elements in series or parallel, depending on the application. The composite fibers can be molded into unlimited user defined shapes and preferably are both flexible and motion sensitive. The fibers are preferably placed where there are rich sources of mechanical movement or waste energy. Examples of areas of mechanical energy input for an exemplary portable electronic device may include a flip open housing, a slide open housing, push buttons, slides, switches, scroll wheels, mounting cradles, holsters, carrying devices, stylus, hand grips or areas where a user picks up and/or holds the device when using the device, and the like.

[0100] A piezoelectric ceramic fiber energy harvesting system offers a less weight, less space, low cost solution to the power problems typically associated with portable electronic devices. A piezoelectric ceramic fiber energy harvesting system can be relatively easy to integrate into the form factor of typically portable electronic devices. Preferably, the physical packaging of the piezoelectric energy harvesting, conversion, and storage systems fit within an existing body or housing of the portable electronic device. More preferably, the piezoelectric energy generating, conversion, and storage systems occupy less space in the device body or housing of a portable electronic device than conventional power sources, such as batteries. For example, the piezo components preferably take the shape of the device itself. Alternatively, the entire or a portion of the piezo components may be located external to the device, such as in an auxiliary device/structure associated with the portable electronic device.

[0101] In another embodiment, the piezoelectric ceramic fiber energy harvesting system may comprise an extreme life-span micro-power supply. The extreme life-span micro-power supply has an extended life expectancy and the piezoelectric ceramic fibers will typically outlast the expected life of the other electronics in the device.

[0102] A piezoelectric ceramic fiber energy harvesting system may provide one or more of the following advantages/benefits over other types of power and other types of energy harvesting systems: reduce/eliminate dependency on external power source; reduce/eliminate dependency on batteries; eliminate battery replacement and battery disposal; make more portable by, for example, reducing/eliminating dependency on power cord; make more portable by, for example, reducing/eliminating dependency on charging station; reduce the size (smaller) of the portable electronic device by, for example, having the fibers conform to the shape of the device; reduce the weight (lighter) of the portable electronic device (piezoelectric ceramic fiber solu-